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Comminuted fish flesh treated with certain salts serves as an effective binding material.

Solubilized Fish Muscle as a Food Binding Material

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INTRODUCTION

Several different binding materials have been used in the past for one food product or another. Among these materials, the most widely used for seafoods is a batter-breading combination in which the binding agent is usually a modified starch. It is used, for example, to manufacture fish sticks or portions and breaded fillets.

Comminuted fish flesh has been proposed as a binder material. Its advantages may include retention of binding qualities upon heating and minimal alteration in texture or taste of final product (Ronsivalli and Learson, 1973). This binder is prepared by grinding fish flesh in a silent cutter and then mixing it with water. Learson et al. (1971) recommended a ratio of 4 parts comminuted fish to 1 part water, but subsequently, they recommended much more dilute mixtures—fish:water ratios of 1:1 to 1:5 (Ronsivalli and Learson, 1973).

Physical treatments such as heating, degree of comminution of the flesh, and amount of added water alter the adhesive properties of this fish binder paste (Ronsivalli and Learson, 1973). The effect of these treatments on structure of muscle proteins are well known (review by Hamm, 1960). Presumably, these physical treatments influence the performance of this fish paste binder in the same manner.

The properties of a fish binder should be influenced by chemical, as well as physical, modification of its proteins. This possibility is not considered in the descriptions of Ronsivalli and Learson (1973) or Learson et al. (1971). The ability of dissolved salts to solubilize muscle proteins is well known. A variety of salts have been used for this purpose in biochemical investigations of the properties of fish, rabbit, beef, or pork muscle proteins. The common effect of these salts is to provide a sufficient ionic strength to extract proteins from muscle. NaCl or KCl have been used more often than other salts for this purpose. A few salts, such as condensed phosphates, are particularly effective at equivalent ionic strengths because they react with specific muscle proteins. Thus, a combination of salt such as NaCl, and a condensed phosphate, such as sodium tripolyphosphate (TPP), might be more effective than either compound alone (Dyer, 1969).

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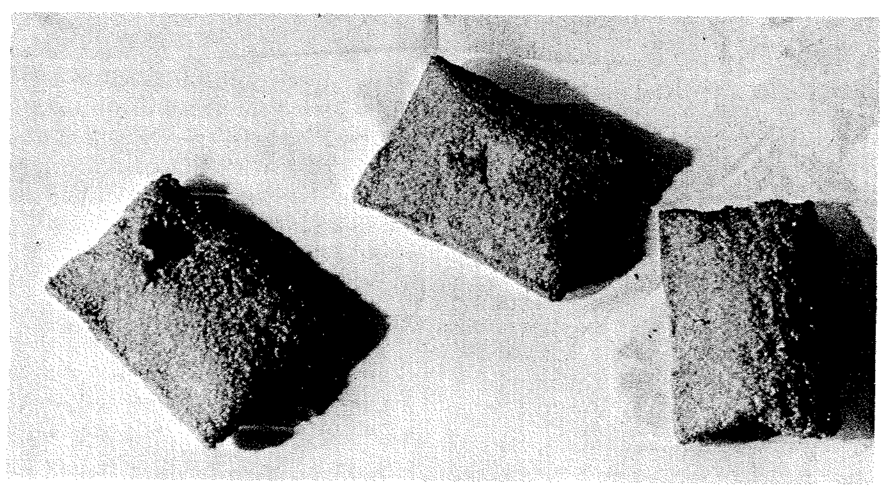
Fillet pieces covered with batter and breading, cooked, vacuum packed, and radiosterilized cryogenically. A commercial starch-based batter was used for the sample at left. A fish paste binder (minced fish and water) was used for the middle sample, and a solubilized fish binder (minced fish plus a 3 percent NaCl-0.5 percent TPP aqueous solution) was used for the sample on the right.

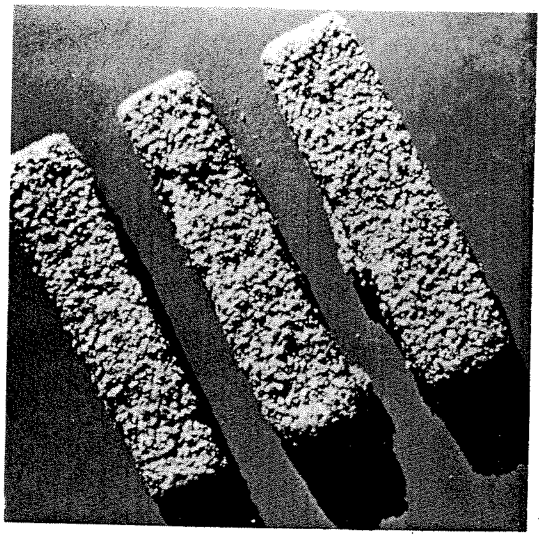


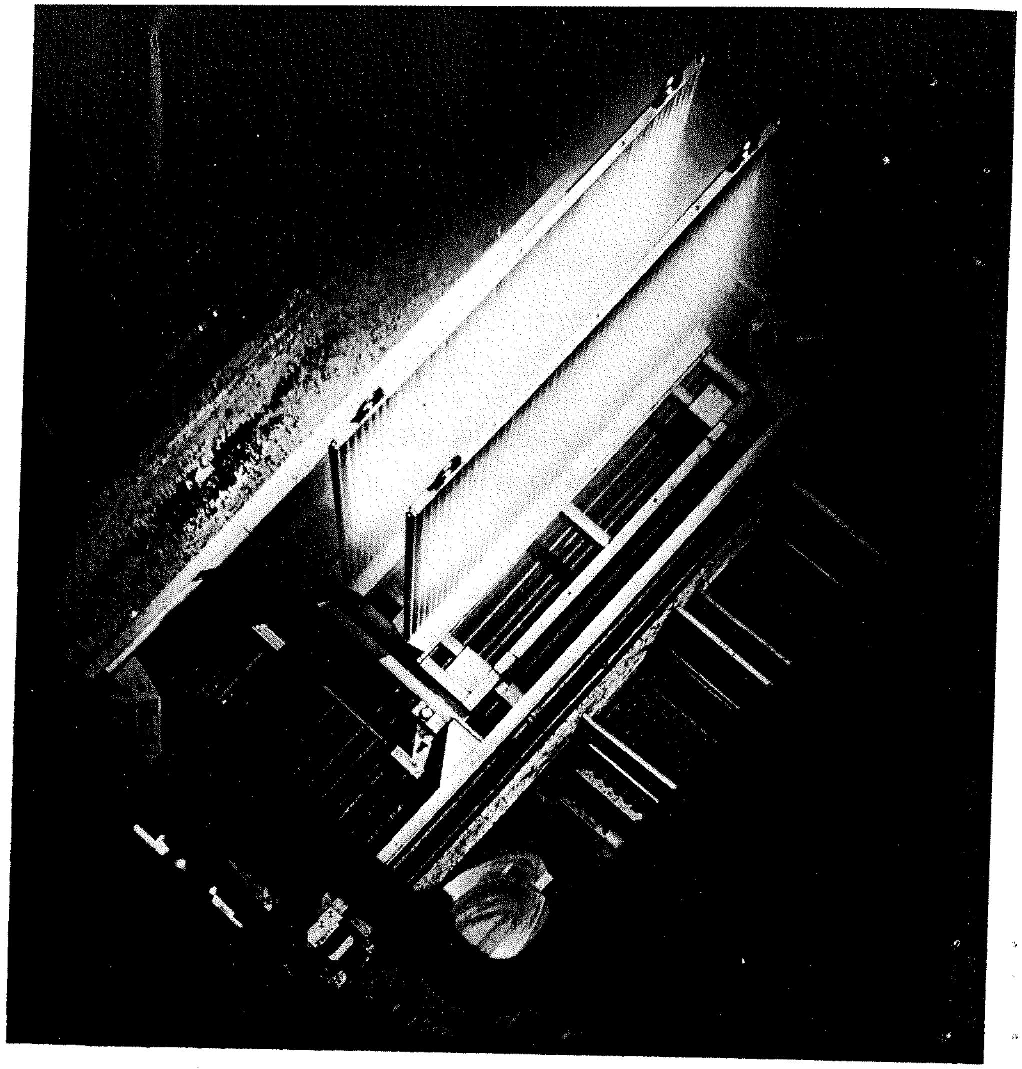
Based on these considerations, an estimate was made of the minimum amounts of NaCl and TPP that would solubilize muscle proteins in a "solubilized fish binder." Shults et al. (1972, 1973) found that a solution of 3 percent NaCl and 0.5 percent TPP had a greater water-holding effect on cooked meats than solutions containing less NaCl. Hellendoorn (1962) calculated that the ionic strength of this solution was 0.6. Dyer et al (1964) estimated that the ionic strength of fish muscle itself is 0.24. Thus a 1:1 mixture of comminuted fish muscle and solution containing 3 percent NaCl and 0.5 percent TPP is estimated to have an ionic strength of 0.42. A considerable amount of myofibrillar protein from fish muscle can be solubilized at 0.4 ionic strength although more protein can be solubilized at 0.5 to 0.6 (King, 1966). At ionic strengths of 0.4 to 0.6, the specific effect of TPP on swelling and moisture retention can be obtained in cooked meat (review by Dyer, 1969).

This estimate is also based on the assumption that ionic strengths can be calculated from molar concentrations of the salts involved. For completely ionized salts such as NaCl, this assumption is valid. However, a concentrated solution of TPP alone (12.5 percent) does not have the effect on fish muscle proteins that would be predicted by calculating its ionic strength from the molar concentration of TPP (F. J. King, unpublished work). Presumably, this discrepancy could be overcome by including activity of the TPP ion in the calculations. However, we are unaware of data which correlate activity of the TPP ion with its molar concentration.

Thus, the purpose of this investigation was to test experimentally the assumption that a solution of 3 percent NaCl and 0.5 percent TPP could be used with minced fish muscle as an effective binder.

Fish sticks made with solubilized fish binder and commercial breading.





Cobalt-60 irradiation source in water storage pool at U.S. Army Natick Laboratories, Natick, Mass.

MATERIALS AND METHODS

Solubilized fish binder was prepared by mixing minced fish flesh with an aqueous solution containing 3 percent NaCl and 0.5 percent TPP (both salts food grade). The fish flesh was minced in a silent cutter or obtained from a meat-bone separator and strainer (King and Carver, 1970). Pollock was used most often but other teleost fish sources should provide equivalent results (Learson et al. 1971). During preparation and use of this binder, we kept the temperature as low as possible without freezing since these conditions favor stability of fish muscle proteins (review by King, 1966). The storage life of this binder was not determined, but it has been kept for from 0 to 4 days at 3°C and performed satisfactorily afterwards.

Pieces of fresh fillets were dipped in the solubilized fish binder and then in Breader (Specialty Products, Inc., Cleveland, Ohio 44142). Then they were cooked in a deep-fat fryer. Time-temperature conditions of this heat treatment were not critical as long as enough heat was supplied to cook the fish and set the binder (Ronsivalli and Learson, 1973).

Adhesion was measured by the coating defect method of U.S. Grade Standards as described in USDI (1963). The adhesiveness of the solubilized fish binder and Breader to fillet pieces was compared to other fillet pieces covered with a commercial batter mix, Batter Bind S (National Starch and Chemical Corp., New York, N.Y.) and Breader.

After this initial evaluation, the effect of the other preservation treatments was determined. Samples of the coated fillets with the covering were packaged under vacuum (appx 125 mm Hg), in epoxy-phenolic enamel-lined cans (404 × 309) and were given a radappertizing (radiation sterilizing) dose in the range of 3.2 to 4.0 Mrad using the NLABS Cobalt-60 source at a dose rate of approximately 30,000 rad/sec. The product temperature was held at −20° to −40°C during irradiation. After irradiation, the samples were stored at 21°C for 0 to 12 months before evaluation.

RESULTS AND DISCUSSION

Compared to a commercial starch-base binder, the solubilized fish binder had greater adhesion to surfaces of uncut muscle. Both binders adhered satisfactorily to freshly cooked fillet pieces. However, only the solubilized fish protein binder retained its adhesiveness after the further treatments of vacuum packaging, freezing, cryogenic radiosterilization and subsequent storage.

The solubilized fish binder performed differently from the fish paste binder of Ronsivalli and Learson (1973). The viscosity of the solubilized binder itself was much lower, even though both binders contained similar proportions of water and minced fish. It also produced a thinner, more flexible coating on fillet pieces. Presumably, this difference results from the effects of NaCl and TPP on ionic strength (estimated final value of 0.4) and in specific effects of TPP on solubilizing muscle protein. Adhesion of this solubilized fish binder to fillet pieces was slightly better than that of the fish paste binder under all the conditions tested.

Attempts were made to adjust the viscosity of the solubilized fish binder and thereby the thickness or flexibility of its coating on fillet pieces. Dilution with a 3 percent NaCl-0.5 percent TPP solution decreased the viscosity of this binder. With up to 5 parts of this solution per 1 part of minced fish, the binder was still effective in covering fillet pieces, and the products did not have a salty or bitter taste. Theoretically, one can increase the binder's viscosity by adding water. If enough water is added and time is allowed for the proteins to become equilibrated to the new ionic milieu, some of the proteins coalesce. However, this approach is less practical in preparing a binder than a direct mixing of minced flesh with a solution having a lower ionic strength.

Ronsivalli and Learson (1973) suggested several food products in which a fish paste is used as a matrix in which pieces of flesh are imbedded. We have not tested the solubilized fish binder for this specific application. However, its adhesiveness to fillet pieces leads us to suggest that, in a matrix application, it could provide a thinner more flexible material than a fish paste binder.

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